

Chapter 8:

Special Compliance Topics

8.0 SUMMARY

This chapter discusses special topics as they apply to the various compliance paths for the *Energy Efficiency Standards* (hereafter standards). These special topics include:

- **Multi-Family Buildings.** Compliance of the building as a whole or unit-by-unit.
- **Mixed Occupancy Buildings.** Compliance of the dominant occupancy alone or each occupancy separately, and how mandatory measures apply.
- **Change in Occupancy.** Compliance requirements when the occupancy of a building changes.
- **Subdivisions and Master Plans.** Multiple orientations of the same plan.
- **Fenestration Products (Glazing).** An explanation of glazing terminology and the thermal performance rating system for all fenestration products.
- **Wood Space Heat.** A description of compliance for wood heat and installation criteria.
- **Controlled Ventilation Crawl Space (CVC).** An explanation of the procedure for analyzing the energy use, as well as a listing of installation requirements, for CVC.
- **Zonal Control.** A description of the procedure for analyzing the energy use of zonally controlled space conditioning, as well as eligibility and installation criteria.
- **Hydronic Space Heating.** An overview of hydronic space-heating systems and compliance calculations.
- **Evaporative Cooling.** A description of the energy credit for evaporative cooling, as well as eligibility and installation criteria.

CHAPTER OVERVIEW:

Part	Topic	Page
8.1	Multi-Family Buildings	8- 2
8.2	Mixed Occupancy Buildings	8- 4
8.3	Change in Occupancy	8- 4
8.4	Subdivisions & Master Plans	8- 5
8.5	Fenestration Products	8- 7
8.6	Wood Space Heating	8- 12
8.7	Controlled Ventilation Crawl Space (CVC)	8- 14
8.8	Zonal Control	8- 15
8.9	Hydronic/Combined Hydronic Space Heating	8- 18
8.10	Evaporative Cooling	8- 22
8.11	Geothermal (Ground Source) Heat Pumps	8- 23
8.12	Duct Credits	8- 23
8.13	Radiant Barriers	8- 26
8.14	Infiltration Reduction Credit— Air Retarders/Housewraps	8- 26
8.15	Log Homes	8- 27
8.16	Solar Energy Systems	8- 28
8.17	Straw Bale Construction	8- 30

Applicable sections of California Code of Regulations Title 24, Part 6: Sections 100(e), 101(b), 110 through 119, 150 through 152.

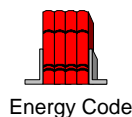
- **Geothermal Heat Pumps.** A description of this type of space conditioning equipment along with efficiency information needed for complying with the standards.
- **Duct Credits.** A description of the energy credit available for constructing tight ducts along with the installation, documentation and diagnostic testing requirements.

- **Radiant Barriers.** A description of the energy credit for radiant barriers, as well as a listing of eligibility and installation requirements.
- **Air Retarders/Housewraps.** A description of the energy credit for air retarders/air barriers or housewraps, as well as some installation guidelines.
- **Log Homes.** An overview of the unique aspects of log homes, and how their special features can be accounted for in demonstrating compliance.
- **Solar Energy Systems.** An overview of thermal solar systems for space-heating and electric photovoltaic systems.
- **Straw Bale Construction.** An overview of the unique aspects of straw bale construction, and how its special features can be accounted for in demonstrating compliance.

For a discussion of other special topics not covered in this chapter, see Appendix G (*Glossary*).

8.1 MULTI-FAMILY BUILDINGS

In a multi-family building, one dwelling unit shares a common wall and/or floor or ceiling with at least one other dwelling unit. The information contained in this *Residential Manual* applies only to low-rise multi-family buildings. See definitions below.



Energy Code

Low Rise vs. High-Rise Multi-family Buildings (Section 101(b))

HABITABLE STORY is a story that contains space in which humans may work or live in reasonable comfort, and that has at least 50 percent of its volume above grade.

HIGH-RISE RESIDENTIAL BUILDING is a building, other than a hotel/motel, of occupancy group R-1 with four or more habitable stories.

LOW-RISE RESIDENTIAL BUILDING is a building, other than a hotel/motel, that is of occupancy group R-1 and is three stories or less, or that is of occupancy group R-3.



Multi-Family Building Compliance

Multi-family apartment buildings with four or more habitable stories (and hotels or motels of any number of stories) are covered by the standards explained in the latest edition of the *Nonresidential Manual for Compliance with the Energy Efficiency Standards*. This category of high-rise residential includes a building with three or fewer stories of residential dwelling units, with a total of four or more habitable stories in the building.

Multi-family buildings with one to three habitable stories are considered low-rise residential buildings and are discussed in this chapter.

For more information about buildings within the scope of the residential standards, including occupancy group R-2 and congregate residences, see Chapter 1, Part 1.3.

Compliance for a low-rise multi-family buildings may either be demonstrated for the building as a whole or on a unit-by-unit basis. Walls between dwelling units are considered to have no heat transfer, and thus are ignored.

Since there are different standards that apply to low-rise multi-family and high-rise multi-family buildings (Chapter 1, Part 1.2), it is important to first verify the number of habitable stories in the building. Only those habitable stories that have more than half of their volume above grade should be counted in determining the number of habitable stories, and all conditioned space should be accounted for.

Whole Building Compliance

The simplest approach to compliance for a multi-family building is to treat the building as a whole, using any of the compliance paths. In practice, this process is similar to analyzing a single-family residence except for some differences in water-heating budgets explained in Chapter 6.

Compliance Unit-By-Unit

The other approach to multi-family buildings is to demonstrate the energy compliance of each dwelling unit separately. This implies modeling each unit in the building by orientation and floor level, thereby showing that the building as a whole complies (see Figure 8-1). In this approach, surfaces which separate dwelling units are ignored as they are assumed to have no heat loss or heat gain associated with them.

Different orientations and locations of each unit type within the building must be considered separately. That is, a one-bedroom apartment on the ground floor of a three-story building is different from the same plan on a middle floor or the top floor, even if all apartments have the same orientation and are otherwise identical.

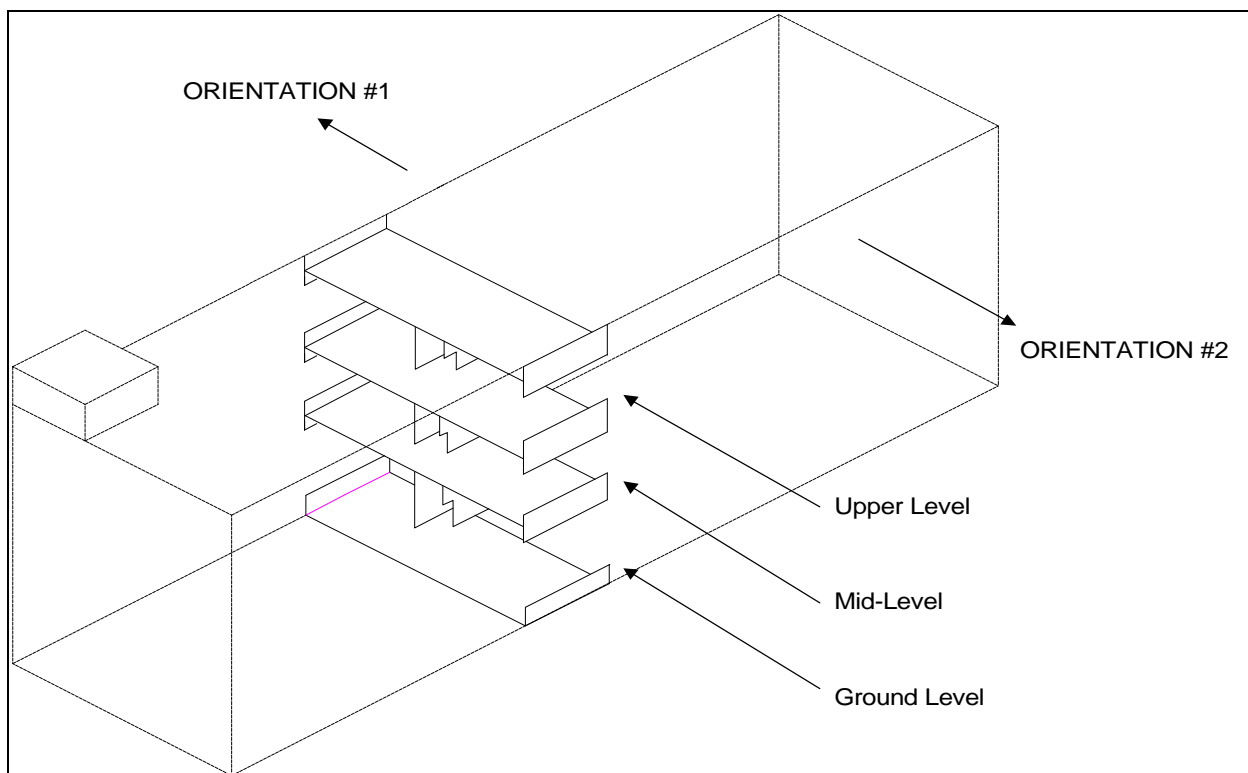
Other options for showing unit-by-unit compliance are similar to those for subdivisions and are explained in Part 8.4 of this chapter.



Examples

Multi-Family Building Compliance

When preparing compliance calculations for a three-story apartment complex, I have the option of showing compliance for each dwelling unit or for the entire building. If I use the individual dwelling unit approach, do I need to provide calculations for every dwelling unit?



**Figure 8-1: Multi-Family Building Option:
Demonstrate Compliance for Each Generic Unit Type in Each of its Characteristic Locations**

Each dwelling unit must comply with the standards when using this approach. When dwelling units have *identical* conditions the calculations be combined. This means you will show separate compliance for all unique conditions, such as:

- Front facing North
- Front facing West
- Front/side walls facing East and North
- Front/side walls facing East and South
- Exterior roof, no exterior floor
- Exterior floor, no exterior roof

Surfaces separating two conditioned spaces (such as common walls) have no heat transfer and can be disregarded in the compliance calculations.

Alternatively, you can model the entire building.

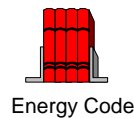
consider when analyzing the energy compliance of a mixed occupancy building is the type and area of each different occupancy.

Depending on the area of the different occupancies, you may be able to demonstrate energy compliance as if the whole building is residential (the mandatory measures of the actual occupancy still apply). This is allowed if the residential occupancy accounts for greater than 90 percent of the conditioned floor area of the building (or permitted space).

NOTE:

Mandatory measures apply to each individual occupancy regardless of the compliance approach used. For example, if complying under the mixed occupancy exception, both residential documentation (MF-1R form) and nonresidential documentation for mandatory measures must be submitted with other compliance documentation.

8.2 MIXED OCCUPANCY BUILDINGS



Mixed Occupancy (Section 100(e))

When a building is designed and constructed for more than one type of occupancy, the space for each occupancy shall meet the provisions of Title 24, Part 6 applicable to that occupancy.

EXCEPTION to Section 100(e): *If one occupancy constitutes at least 90 percent of the conditioned floor area of the building, the entire building may comply with the provisions of Title 24, Part 6 applicable to that occupancy, provided that the applicable mandatory measures in Sections 110 through 139, and 150, are met for each occupancy.*

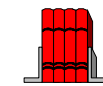


Mixed Occupancy

Some residential buildings have areas of other occupancies, such as retail or office, in the same building. An example of this might be a three-story building with two floors of apartments above ground floor shops and offices. The first thing to

If the building design does not fit the criteria described above for a dominant occupancy, then each separate occupancy must be shown to comply on its own. This may be done by using any of the approved prescriptive or performance methods available for each occupancy type. As a result, documentation for each occupancy type must also be considered separately, and a Certificate of Compliance must be submitted for each occupancy.

8.3 CHANGE IN OCCUPANCY



Change in Occupancy (Section 152(b))

Section 152. Energy Efficiency Standards For Additions and Alterations In Existing Buildings that will be Low-rise Residential Occupancies

...

- (b) *Alterations. Alterations . . . in conjunction with a change in building occupancy to a low-rise residential occupancy shall meet either 1 or 2 below.*

[See Chapter 7, Part 7.5, for the full text of Section 152(b).]



Change in Occupancy

A change in occupancy of a currently conditioned space is treated as if the new occupancy had existed previously within the same space. Compliance is demonstrated using the rules that apply to alterations (see Chapter 7, Part 7.5). Only those components of the building that are being modified must comply.

8.4 SUBDIVISIONS AND MASTER PLANS



Compliance Requirements for Subdivisions and Master Plans

Subdivisions often require a special approach to energy compliance, since they generally include one or more basic building or unit plans repeated in a variety of orientations. The basic floor plans, as drawn, may also be used in a mirror image or reversed configuration.

There are three compliance options for subdivisions. They are:

1. Model each individual building, or building condition, separately according to its actual orientation.
2. Model all four cardinal orientations for each building or unit plan type with identical conservation features for no orientation restrictions.
3. Model all four cardinal orientations for each building or unit plan type with different shading features in each orientation.

NOTE: The Commission considered other options for subdivisions and master plans. However, such options greatly increase the complexity of plan checking and field inspecting and were thus rejected.

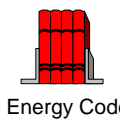


Subdivisions and Master Plans

Individual Building Approach

The most straightforward compliance option for subdivisions is to analyze each individual building in the project separately using any compliance method. This may be practical for subdivisions with only custom buildings, or with only one or two specific orientations for each building plan.

This approach requires that each unit be shown to comply, with separate documentation submitted for each unit plan in the orientation in which it will be constructed.



Compliance Requirements for Performance Standards, Multiple Orientations (Section 151(c))

The application for a building permit shall include documentation which demonstrates, using an approved calculation method, that the new building has been designed so that its energy use from depletable energy sources does not exceed the combined water heating and space conditioning energy budgets for the appropriate climate zone.

...

MULTIPLE ORIENTATION ALTERNATIVE to Section 151(c): A permit applicant may demonstrate compliance with the energy budget requirements of Section 151(a) and (b) for any orientation of the same building model, if the documentation demonstrates that the building model with its proposed designs and features would comply in each of the four cardinal orientations.

In the four compliance demonstrations, all designs and features must be the same, except that a model may differ in its shading in order to show compliance in the four cardinal directions.



Subdivisions and Master Plans (continued)

Multiple Orientation Alternative: No Orientation Restrictions

The computer method may be used to demonstrate that a single family dwelling plan or a unit plan in a multi-family building complies regardless of how it is oriented within the same climate zone (Figure 8-2).

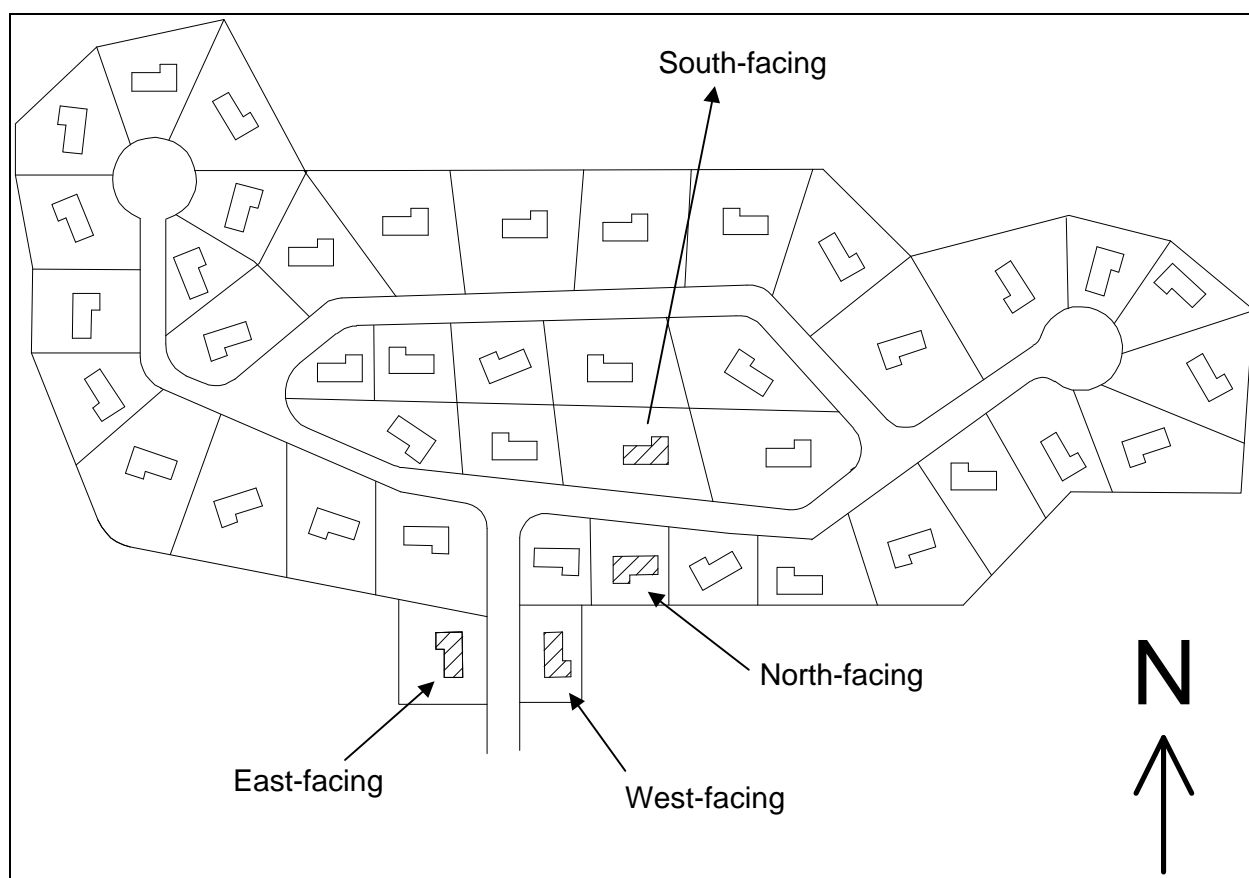
To assure compliance in any orientation, the annual energy consumption must be calculated in each of the four cardinal orientations: true north, true east, true south and true west.

NOTE:

With this option, the buildings must have the identical combination of conservation measures and levels in each orientation and comply with the energy budget in each case.

This method differs from the option explained in the next section in that each building or unit covered by the analysis must include identical features, including shading features, regardless of the orientation.

If a building floor plan is reversed, either the original plans or the reversed plans may be shown to comply in all four cardinal orientations. Multi-family buildings may be analyzed as a whole building using this method or on a unit-by-unit approach at the option of the permit applicant.



**Figure 8-2: Subdivisions and Master Plans Option:
Demonstrate Compliance for Each Cardinal Orientation for Each Basic Model Type**

For compliance, submit documentation of the energy budgets for each of the four orientations. In some cases this documentation will be four C-2Rs, while some computer programs generate this information on one form. One CF-1R form is required.

Multiple Orientations: Orientation Restrictions

Performance methods may be used to demonstrate that a building type or unit plan type in a multi-family building complies *with orientation restrictions*. This approach is allowed when shading is to be selectively applied according to the direction the building faces (as documented on the CF-1R form under the heading "Special Features/ Remarks").

Orientation restrictions automatically apply when the shading measures applied to the same plan vary to achieve compliance in each cardinal orientation.

Each specific combination of shading features is modeled for the cardinal orientation—true north, true east, true south or true west—in which it is to be built, and compliance must be demonstrated in each instance.

With this approach, each building or unit covered by the analysis must be constructed with the specific set of shading features which demonstrate compliance in that orientation.

For compliance, submit documentation of the energy budgets for each of the four orientations—four C-2Rs. One CF-1R form, with the variations in shading features indicated in the "Special Features/ Remarks" section, is required to be submitted and "on the plans" (see Chapter 1).



Examples

Subdivisions and Master Plans

Example 8-1 Multiple Orientations: No Orientation Restrictions

A single family unit plan in Climate Zone 3 has been calculated by an approved computer method to have an energy budget of 27.89 kBtu/ft²-yr. The proposed design is modeled in all

four orientations with no required shading and no variation in any other conservation measure. The following predicted energy use is calculated:

Front North	= 24.65 kBtu/ft ² -yr
Front East	= 26.41 kBtu/ft ² -yr
Front South	= 27.07 kBtu/ft ² -yr
Front West	= 27.83 kBtu/ft ² -yr

Since the energy consumption is less than 27.89 kBtu/ft²-yr in all cases, the unit plan may be constructed in any orientation within Climate Zone 3.

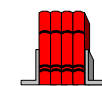
Example 8-2 Multiple Orientations: Orientation Restrictions

The same unit plan (Example 8-1) is to be constructed in Climate Zone 12. The energy budget for the unit plan in the new climate zone is calculated to be 39.22 kBtu/ft²-yr. The proposed design is modeled in all four orientations with interior blinds on approximately 80 percent of the "front" and "rear" fenestration areas when the front faces east or west. No interior blinds are proposed when the front faces north or south. The results are as follows:

Front North	= 35.56 kBtu/ft ² -yr
Front East	= 33.98 kBtu/ft ² -yr
Front South	= 38.68 kBtu/ft ² -yr
Front West	= 39.04 kBtu/ft ² -yr

Again all cases may be constructed.

8.5 FENESTRATION PRODUCTS



Energy Code

Fenestration Products (Section 101(b))

Definitions

DUAL-GLAZED GREENHOUSE WINDOWS are a type of dual-glazed fenestration product which adds conditioned volume but not conditioned floor area to a building.

EXTERIOR DOOR is a door through an exterior partition that is opaque or has a glazed area that is less than or equal to one-half of the door area. Doors with a glazed area of more than one-half of the door area are treated as a fenestration product.

FENESTRATION PRODUCT is any transparent or translucent material plus any sash, frame, mullions, and dividers, in the envelope of a building, including, but not limited to: windows, sliding glass doors, french doors, skylights, curtain walls, garden windows, and other doors with a glazed area of more than one-half of the door area.

SKYLIGHT is glazing having a slope less than 60 degrees from the horizontal with conditioned space below, except for purposes of complying with Section 151(f), where a skylight is glazing having a slope not exceeding 4.76 degrees (1:12) from the horizontal.

SOLAR HEAT GAIN COEFFICIENT (SHGC) is the ratio of the solar heat gain entering the space through the fenestration area to the incident solar radiation. Solar heat gain includes directly transmitted solar heat and absorbed solar radiation, which is then reradiated, conducted, or convected into the space.

WINDOW is glazing that is not a skylight.



Introduction

Fenestration Products

Below is a discussion of how fenestration works, how features of the product affect its rated efficiencies (U-value and SHGC), terminology and general compliance information. In addition:

- Certification, labeling and mandatory requirements for fenestration products are included in Chapter 2.
- Additions and alterations compliance issues related to fenestration are discussed in Chapter 7.
- Fenestration topics related to prescriptive and computer compliance are found in Chapters 3 and 5.



Useful Information

Energy Impacts of Fenestration Products

Windows, glazed doors and skylights have a significant impact on energy use in a home. They account for up to 50 percent of residential space-conditioning energy. The size, orientation and types of installed fenestration products can dramatically affect the overall energy performance of a house. If designed properly, windows can add heat to a space in the winter, lowering heating bills.

Fenestration products can be responsible for up to 50 percent of heat loss in the winter and up to 50 percent of the heat gain in the summer. The U-value and the SHGC both contribute to maintaining overall thermal comfort and energy performance throughout the year. Properly operating shading year round curtains heat gain in the summer, but reduces the need for heating in the winter. Likewise, the U-value is important in reducing conductive heat gain in hot climates.

Two important factors in determining window performance are U-value and SHGC:

- U-value is a measure of how much heat travels through a fenestration product. *The lower the U-value, the more energy efficient the product.*
- SHGC is a measure of the relative amount of heat gain from sunlight that passes through a fenestration product. *The lower the SHGC, the better it is able to keep out solar radiation.*

The U-value and the SHGC both contribute to winter and summer overall thermal comfort and energy performance.

Several parameters control the thermal performance of fenestration products. These include:

- Frame materials, design and configuration (including cross-sectional characteristics)
- Number of panes of glazing
- Gap width (i.e., the distance between panes)
- Window type (i.e., casement versus double hung)

- Glass surface coatings and/or films
- Gas infill type (i.e., type of gas filling the space between panes of glass)
- Spacer material (i.e., the type of material separating multiple panes of glass)

Fenestration is usually framed in either wood, aluminum, vinyl or composites of these. Frame materials such as wood and vinyl are better insulators than metal. Some aluminum-framed units have *thermal breaks* that reduce the conductive heat transfer through the framing element as compared with similar units that have no such conductive thermal barriers.

Dual glazing offers opportunities for improving performance beyond the dimension of the air space between panes. For example, special materials that reduce emissivity of the surfaces facing the air space, including so-called *low-e* (low-emissivity) or other coatings, improve the thermal performance of fenestration products through the glass. Fill gases other than dry air – such as carbon dioxide, argon or krypton – also improve thermal performance.



Useful Information

Descriptions of Fenestration Terms

The following is a brief description of some common terms associated with fenestration products:

Center of Glass U-Value: The U-value measured only through the glass more than 2.5 inches from dividers or the edge of the glass.

Dividers (Muntins): Elements that actually or visually divide different lites of glass. These may be true divided lites, between the panes, and/or applied to the exterior or interior of the glazing.

Edge of Glass: The area of glazing within 2.5 inches of the spacer.

Frame Types:

- **Thermal Break:** Metal frames that are not solid metal from the inside to the outside, but are separated in the middle by a material, usually vinyl, with a significantly lower conductivity.

- **Vinyl:** A polyvinyl chloride (PVC) compound used for frame and divider elements with a significantly lower conductivity than metal and a similar conductivity to wood.

Gap Width: The distance between glazings in multi-glazed systems (e.g., dual or triple glazing). This dimension is measured from inside surface to inside surface. Some manufacturers may report "overall" IG unit width which is measured from outside surface to outside surface.

Gas Infill: Air, argon, krypton, carbon dioxide, SF6 or a mixture of these gases, placed in the space between the panes of dual or triple glazing.

Grilles: See Dividers.

IG Unit: Insulating glass unit. An IG unit includes the glazings, spacer(s), films (if any), gas infills and edge caulking.

Lights or Lites: a layer of glazing material, especially in a multi-layered IG unit.

Low E Coating (low emissivity metallic coating): A transparent metallic coating applied to glazing that reduces its emissivity, and therefore improves its thermal performance. Low E glazing has a better (lower) U-value than standard glazing. Types of Low E coatings include:

- **Soft Coat:** A sputter applied coating sprayed on at a high temperature. These coatings are usually susceptible to degradation (i.e., oxidation) from contact through handling and storing, but generally provide a lower emissivity, and therefore better thermal performance, than hard coatings.
- **Hard Coat:** Low emissivity metallic coatings applied pyrolytically at or near the melting point of the glass so that it bonds with the surface layer of glass. Hard coatings are not subject to oxidation or scratching as the soft coatings are, and new hard coat technologies provide performance very close to that of the soft coatings.

Mullion: Vertical framing member separating adjoining window or doors.

Muntins: See Divider.

Spacer: A material that separates multiple panes of glass in an insulating glass unit. Types of spacers include:

- **Aluminum:** Metal channel that is used either against the glass (sealed along the outside edge of the insulated glass unit), or separated from the glass by one or more beads of sealant.
- **"Insulating":** Non-metallic, fairly non-conductive materials, usually rubber compounds.
- **Others:** Wood, fiberglass and composites.

Suspended Films: Plastic films, stretched between the elements of the spacers between panes of glazing, which act as radiant reflectors to slow the heat loss from the interior to the exterior.



Useful Information

Certification of U-value for Fenestration Products

U-value Rating

The U-value is the total amount of heat that flows through a fenestration product at a given difference in temperature between the interior and exterior surfaces, including the frame, edge of glass and muntins, in Btu/hr-ft²-°F.

As required by Section 116 of the standards, there are two procedures for establishing the U-value of fenestration products:

- The National Fenestration Rating Council NFRC-100-91 (1991) or NFRC 100 (1997); or
- Default U-values (see Chapter 2).

Estimating the rate of heat transfer through framing elements of a fenestration product is complicated by the variety of frame configurations for operable windows, the different combinations of materials used for sash and frames, and the difference in sizes available in various applications. The NFRC rating system makes the differences uniform, so that an entire fenestration product line is assumed to have only two typical sizes, one for residential and one for nonresiden-

tial. The NFRC rated U-value may be obtained from a directory of certified fenestration products, directly from a manufacturer's listing in product literature, or from the product label.

IMPORTANT NOTE:

Each general type of fenestration product (e.g., double wood-frame Low-E or double metal-frame thermal break) has within it a wide range of U-values. Therefore, it is impossible to predict the U-value of a specific product without obtaining the NFRC U-value rating. Consult the NFRC's fenestration product directory or the manufacturers listed NFRC U-value ratings carefully when selecting a U-value to use in compliance calculations.



Compliance/
Plan Check

U-value for Product Specification

When performing compliance calculations and preparing documentation, consult a directory of fenestration products which contains the certified U-value ratings. One such directory is available from NFRC (see Appendix E).

If the exact make and model number of the fenestration products to be installed is not known, there are a few options:

- Look up the U-values for a number of the products most likely to be installed, and use the highest value of those products. Whichever fenestration product is then installed will comply with the U-value used in the calculation.
- Specify a particular product and state "or equivalent." In this approach, the builder or installer must understand that the U-value of the installed product must match, or be less than, the U-value specified in the compliance documentation.
- Use the appropriate default U-value from Table 1-D of Section 116 of the standards (see Chapter 2). The disadvantages of this approach are that:
 - (a) There is no guarantee that a selected product will have the same or better

performance than the U-value assigned to that generic type; or,

- (b) The U-value in the table may be much higher than the actual installed U-value so that additional efficiency measures may be required for compliance.



Useful Information

Certification of SHGC for
Fenestration Products

Solar Heat Gain Coefficient (SHGC)

The SHGC is the measure of how well a fenestration product limits solar heat gain entering the space through the fenestration. This value includes the effects of the frame which also effect how much solar heat enters the building.

As required by Section 116 of the standards, there are two procedures for establishing the SHGC of fenestration products:

- The National Fenestration Rating Council NFRC 200 (1995); or,
- Default SHGC values (see Chapter 2).

SHGC values are between 0 and almost 1, with 1.00 representing no ability to limit solar heat gain. *The lower the SHGC, the better the fenestration product rejects heat.*

For a full explanation of shading, SHGC and shading calculations including the effects of framing divider factors, interior blinds and exterior sunscreens, see *Shading* in the *Glossary*.

NOTE:

Low-e coatings lower the SHGC in addition to reducing heat loss, but there is no direct relationship between emissivity and SHGC. For example, a dual glazed unit with an emissivity of 0.22 may have an SHGC of 0.73 – nearly identical to clear dual glazing - or it may have an SHGC of 0.60, much better than clear dual glazing.



Compliance/
Plan Check

SHGC Specification

When performing compliance calculations and preparing documentation, consult a directory of fenestration products that contains the certified SHGC ratings. One such directory is available from NFRC (see Appendix E).

If the exact make and model number of the fenestration products to be installed is not known, there are a few options:

- Look up the SHGC value for a number of products most likely to be installed, and use the highest value of those products. Whichever fenestration product is then installed will comply with the SHGC value used in the calculation.
- Specify a particular product and state "or equivalent." In this approach, the builder or installer must understand that the SHGC value of the installed product must match or be less than the SHGC value specified in the compliance documentation.
- Use the appropriate default SHGC value from Table 1-E of Section 116 of the standards (see Chapter 2). The disadvantages of this approach are that:
 - >> There is no guarantee that a selected product will have the same or better performance than the U-value assigned to that generic type; or,
 - >> The SHGC value in the table may be much higher than the actual installed SHGC so that additional efficiency measures may be required for compliance.



Construction

Fenestration Products

The fenestration product installer needs to understand the required U-values and product SHGC values for the specific project, based on the compliance documentation such as the Certificate of Compliance (CF-1R). The installer should check the documentation to insure that

the products have the temporary label on the center of the glazing which meets the compliance requirements.

The U-value for compliance with the residential standards is the "AA" size. Make sure the "AA" size U-value is the same as, or less than, the U-value used in the compliance documentation. The temporary label must remain on the product until the field inspector has inspected it.

See Chapter 2 for a complete discussion of Installation Certificate (CF-6R form) and the responsibility for completing this form as required by Section 10-103 (Administrative Regulations)

8.6 WOOD SPACE HEATING



Energy Code

Wood Heater (Section 101(b))

WOOD HEATER is an enclosed wood burning appliance used for space heating and/or domestic water heating, and which meets the definition in Federal Register, Volume 52, Number 32, February 18, 1987.



Introduction

Wood Heater

An exceptional method establishes guidelines for use of wood heaters with standards compliance (Energy Commission approved according to Title 24, Part 1, Section 10-109 based on Compliance Options Technical Analysis, Contract #400-85-028).

Eligibility Criteria

- A. The building department having jurisdiction must determine that natural gas is not available;

NOTE:

Liquefied petroleum gas, or propane, is not considered natural gas.

- B. The local or regional air quality authority must determine that their authorization of this exceptional method is consistent with state and regional ambient air-quality requirements pursuant to Sections 39000 to 42708 of the California Health and Safety Code;
- C. The wood heater must be installed in a manner which meets the requirements of all applicable health and safety codes, including, but not limited to, the requirements for maintaining indoor air quality of the *Uniform Mechanical Code*, in particular those homes where vapor barriers are installed (see Chapter 2);
- D. The wood heater must meet the EPA definition of a wood heater as defined in the Federal Register, Vol. 52, No. 32, February 18, 1987 (see below);
- E. The performance of the wood heater must be certified by a nationally recognized agency and approved by the building department having jurisdiction, to meet the performance standards of the EPA;
- F. The rated output of the wood heater must be at least sixty percent (60%) of the design heating load, using calculation methods and design conditions as specified in Section 150(h) of the standards (see Chapter 2);
- G. A backup heating system must be installed. At the discretion of the local enforcement agency it may be designed to provide all of the design heating load, using calculation methods and design conditions as specified in Section 150(h) of the standards;

- H. The wood heater must be located such that transfer of heat from the wood heater is effectively distributed throughout the entire residential unit or must be used in conjunction with a mechanical means of providing heat distribution throughout the dwelling.

Habitable rooms separated from the wood heater by one free opening of less than 15 square feet or two or more doors must be provided with a positive heat distribution system, such as a thermostatically controlled fan system. Habitable rooms do not include closets or bathrooms.

Wood heaters on a lower level are considered to heat rooms on the next level up, provided they are not separated by two or more doors.

- I. The wood heater must be installed according to manufacturer and local enforcement agency specifications and must include instructions for homeowners which describe safe operation;
- J. The local enforcement agency may require documentation that demonstrates that a particular wood heater meets any and all of these requirements.

Equipment Criteria

The federal register includes minimum criteria for wood heaters, established by the Federal Environmental Protection Agency. This criteria defines a wood heater as:

... an enclosed, wood burning appliance used for space heating, domestic water heating, or indoor cooking that meets all of the following criteria:

1. *An air-to-fuel ratio averaging less than 35 to 1,*
2. *Firebox volume less than 20 cubic feet,*
3. *Minimum burn rate less than 5 kilogram/hour (11.0 lbs/hr), and*
4. *Maximum weight of less than 800 kilograms (1762 lbs).*

The federal rules explicitly exclude furnaces, boilers and open fireplaces, but include wood-heater inserts.



Compliance/
Plan Check

Wood Space Heating

The Energy Commission's exceptional method for wood heaters with any type of backup heating is available in areas where natural gas is not available. If the required eligibility criteria are met, a building with one or more wood heaters may be shown to comply with the standards using one of the following methods:

NOTE:

Duct efficiency credits may *not* be taken, as the combined wood heater/backup-heating system is assumed to be equivalent to a 78 percent AFUE central furnace with R-4.2 ducts in the attic.

Prescriptive Approach

The building envelope conservation measures of any one of the Alternative Component Packages must be installed, and the overall heating system efficiency for the wood heater and its backup-heating system may be assumed to be equivalent to that required by the package.

Performance Approach

A computer method may be used for compliance, with the overall heating system efficiency for the wood heater and its backup-heating system assumed to be equivalent to a 78 percent AFUE central furnace with R-4.2 ducts in the attic. The backup-heating system is not included in the compliance calculations.

NOTE:

If all of the criteria for the wood heat exceptional method is not met, the backup-heating system must be included in the compliance calculations as the primary heat source.

Wood Water Heating

Credit is available for the use of wood heat with water heating systems. See Wood Stove Boilers in Chapter 6, Part 6.6.



Wood Heat

Examples

Are pellet stoves treated the same as wood stoves for the purposes of standards compliance?

Yes.

If a wood stove is installed in a wall, does it have to meet the fireplace requirements of standards Section 150(e)?

No. A wood stove that meets EPA certification requirements does not have to meet any requirements applicable to fireplaces.

8.7 CONTROLLED VENTILATION CRAWL SPACE (CVC)



Introduction

Controlled Ventilation Crawl Space

The Energy Commission has approved an exceptional method for analyzing the energy impact of buildings with raised floors which use foundation wall insulation and have automatically controlled crawl-space vents. The method is available as an option using an approved computer method with unique modeling criteria explained in Chapter 5, Part 5.4K.



Construction

Controlled Ventilation Crawl Space

The following steps must be taken, *and the approach must be approved by the local building department*, for the raised-floor building to show compliance with the standards under this exceptional method:

Drainage

Proper enforcement of site engineering and drainage, and emphasis on the importance of

proper landscaping techniques in maintaining adequate site drainage, is critical.

Ground Water And Soils

Local ground water tables at maximum winter recharge elevation should be below the lowest excavated site foundation elevations. Sites that are well drained and that do not have surface water problems are generally good candidates for this stem-wall insulation strategy. However, the eligibility of this alternative insulating technique is entirely at the building officials' discretion. Where disagreements exist, it is incumbent upon the applicant to provide sufficient proof that site drainage strategies (e.g., perimeter drainage techniques) will prevent potential problems.

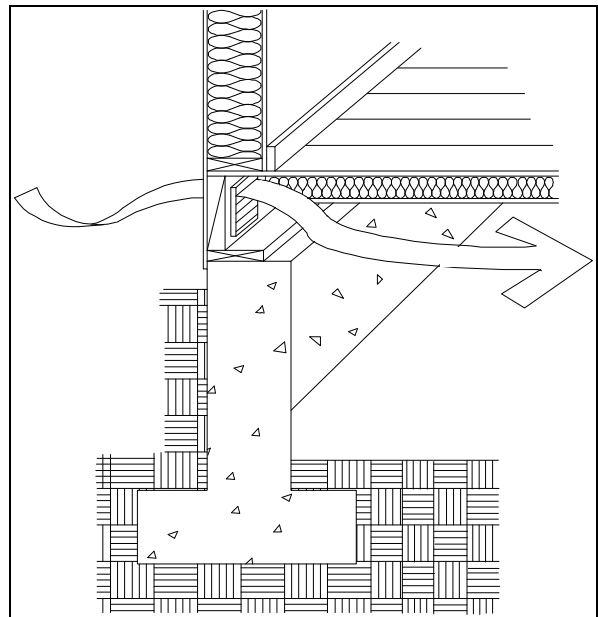


Figure 8-3: Controlled Ventilation Crawl Space

Ventilation

All crawl space vents must have automatic vent dampers to receive this credit. Automatic vent dampers must be shown on the building plans and installed. The dampers should be temperature actuated to be fully closed at approximately 40°F and fully open at approximately 70°F.

Cross ventilation consisting of the required vent area reasonably distributed between opposing foundation walls is required.

Foam Plastic Insulating Materials

Foam plastic insulating materials must be shown on the plans and installed when complying with the following requirements:

- **Fire Safety**—*UBC* Section 1712(b)2. Products shall be protected as specified. Certain products have been approved for exposed use in under floor areas by testing and/or listing.
- **Direct Earth Contact**—Foam plastic insulation used for crawl-space insulation having direct earth contact shall be a closed cell water resistant material and meet the slab-edge insulation requirements for water absorption and water vapor transmission rate specified in the mandatory measures.

Mineral Wool Insulating Materials

- **Fire Safety**—*UBC* Section 1713(c). "All insulation including facings, such as vapor barriers or breather papers installed within ... crawl spaces ... shall have a flame-spread rating not to exceed 25 and a smoke density not to exceed 450 when tested in accordance with *UBC*. Standard No. 42-1." In cases where the facing is also a vapor retarder, the facing shall be installed to the side that is warm in winter.
- **Direct Earth Contact**—Mineral wool batts shall not be installed in direct earth contact unless protected by a vapor retarder/ground cover.

Vapor Barrier (Ground Cover)

A ground cover of 6 mil (0.006 inch thick) polyethylene, or approved equal, shall be laid entirely over the ground area within crawl spaces.

- The vapor barrier shall be overlapped six inches minimum at joints and shall extend over the top of pier footings.
- The vapor barrier should be rated as 1.0 perm or less.
- The edges of the vapor barrier should be turned up a minimum of four inches at the stem wall.
- Penetrations in the vapor barrier should be no larger than necessary to fit piers, beam supports, plumbing and other penetrations.

- The vapor barrier must be shown on the plans and installed.

Studies show that moisture conditions found in crawl spaces that have minimal ventilation do not appear to be a significant problem for most building sites provided that the crawl-space floors are covered by an appropriate vapor barrier and other precautions are taken. The Energy Commission urges building officials to carefully evaluate each application of this insulating technique in conjunction with reduced ventilation because of the potential for adverse effects of surface water on crawl-space insulation that could negate the energy savings predicted by the procedure.

8.8 ZONAL CONTROL



Introduction

Zonally Controlled Space
Conditioning

An energy compliance credit is provided for zoned heating and air-conditioning systems which save energy by providing selective conditioning for only those areas of a house that are occupied. A house having at least two zones (living and sleeping) with separate thermostats controlling temperatures in the zones, and with a maximum noncloseable opening of 40 square feet may qualify for this compliance credit. The equipment may consist of one air-conditioning system for the living areas and another system for sleeping areas or a single system with zoning capabilities, set to turn off the sleeping areas in the daytime and the living area unit turned off at night. (See Figure 8-4).



Energy Code

Zone (Section 101(b))

ZONE, SPACE CONDITIONING is a space or group of spaces within a building with sufficiently similar comfort conditioning requirements so that comfort conditions, as specified in 144(b)3 or 150(h), as applicable, can be maintained throughout the zone by a single controlling device.

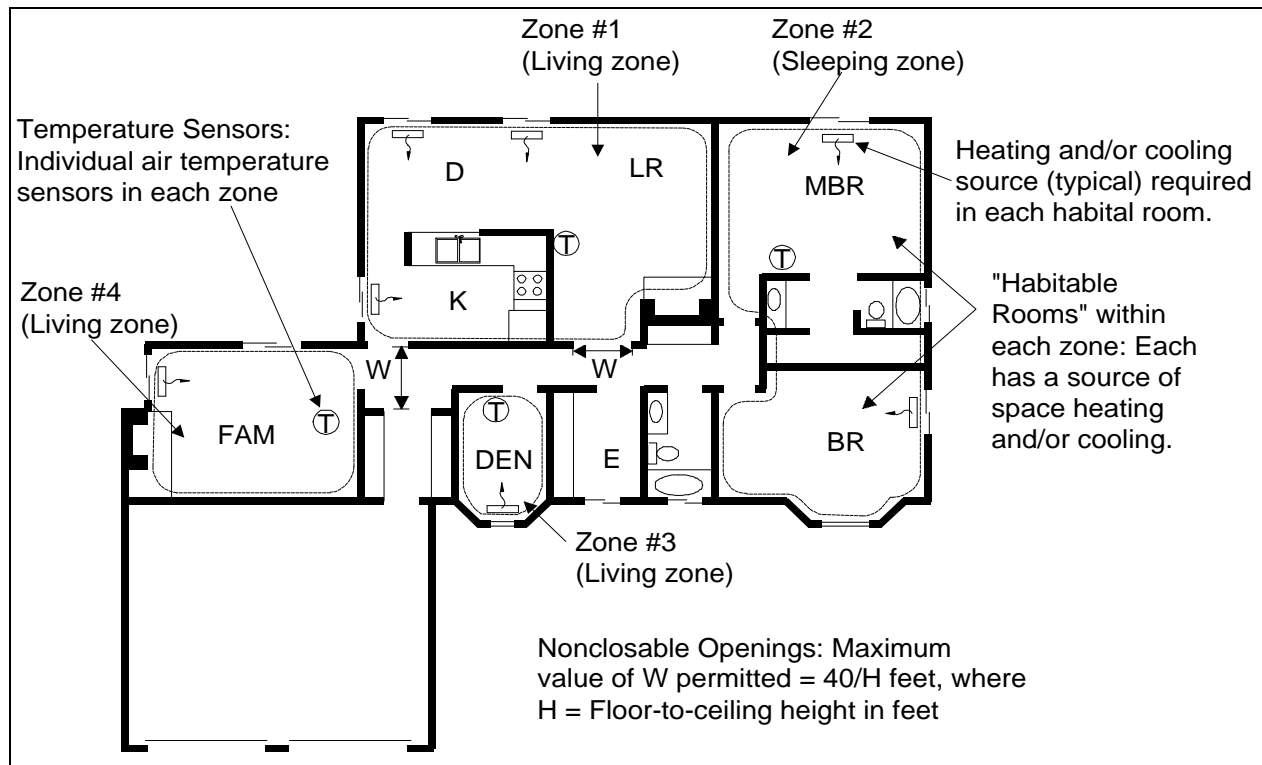


Figure 8-4: Zonal Control Requirements for Energy Credit



Compliance/
Plan Check

Zonally Controlled Space Conditioning

A procedure for analyzing the energy impact of zonally controlled space-heating and -cooling systems has been approved by the Energy Commission as an exceptional method (Energy Commission approved according to Title 24, Part 1, Section 10-109 based on Compliance Options Approval Request, May 14, 1985). The method is available as an option using a computer performance approach and specific modeling criteria (Chapter 5, Part 5.4L).

NOTE:

Although multiple thermally distinct living and/or sleeping zones may exist in a residence, the correct way to model zonal control credit requires only two zones: one living zone and one sleeping zone. All separate living zone components must be modeled as one single living zone, and the same must be done for sleeping zones.



Construction

Zonally Controlled Space Conditioning

There are unique eligibility and installation requirements that must be met in order for this zonal control method to receive conservation credit. The following steps must be taken for the building to show compliance with the standards under this exceptional method:

Temperature Sensors

Each thermal zone, including a living zone and a sleeping zone, shall have individual air temperature sensors.

Habitable Rooms

Each habitable room in each zone shall have a source of space heating and/or cooling (if zonal credit for cooling is desired) such as forced air supply registers or individual conditioning units. Habitable rooms shall not include bathrooms, laundry, halls and/or dressing rooms.

Noncloseable Openings

The total noncloseable opening area between adjacent living and sleeping thermal zones (i.e., halls, stairwells or other openings) shall be less than or equal to 40 square feet. All remaining zonal boundary areas shall be separated by permanent floor to ceiling walls and/or fully solid operable doors capable of restricting free air movement when in the closed position.

Setback Thermostats

Each zone shall be controlled by a central automatic dual setback thermostat that can control the conditioning equipment and maintain preset temperatures for varying time periods in each zone independent of the other.

1. Each zone must have automatic dual setback control for heating, and setup control for cooling if cooling, is provided.
2. Thermostat locations in each zone must provide accurate temperature readings of the typical condition in that zone.
3. The control may be switched from heating to cooling mode manually.
4. The control must be programmable by the occupant.
5. For residences using heat pump systems, the automatic setback thermostat must have two-stage heating which incorporates a recovery ramp of other logic that will minimize electric resistance heating.

Forced Air Ducted Systems

1. Each zone must be served by a return air register located entirely within the zone. Return air dampers are not required.
2. Dampers shall be manufactured and installed so that when they are closed, there is no measurable air flow at the registers.

3. The system must be designed to operate within the equipment manufacturer's specifications.
4. Air is to positively flow into, through and out of a zone only when the zone is being conditioned. No measurable amount of supply air is to be discharged into unconditioned or unoccupied space in order to maintain proper air flows in the system.
5. Systems that allow supply air to be bypassed to the return-air system shall be protected against short cycling and excessive temperatures of the space-conditioning equipment, and include necessary controls for efficient, safe and quiet operation.



Examples

Zonal Control

In defining the living and sleeping zones for a home with a zonally controlled HVAC system, can laundry rooms and bathrooms (which are not habitable spaces) be included on whichever zone they are most suited to geographically (e.g., a bathroom located near bedrooms)?

Yes. For computer modeling, include the square footage of any nonhabitable, or indirectly conditioned spaces, with the closest zone.

I have two HVAC systems and want to take zonal control credit. Can the return air for both zones be located in the hallway (living zone)?

No. Because of the need to prevent mixing of air between the conditioned zone and the unconditioned zone, it is necessary to (1) have the return air for each zone within that zone, and (2) limit any noncloseable openings between the two zones to 40 square feet or less. Unless these criteria, in addition to the other criteria listed in this Chapter can be met, credit for a zonally controlled system cannot be taken.

8.9 HYDRONIC/COMBINED HYDRONIC SPACE HEATING



Introduction

Hydronic Heating

Hydronic heating is the use of water as a heat delivery medium in a space-heating system. Figure 8-5 shows a simple schematic illustrating some of the components in a hydronic-heating system. A hydronic-heating system consists of five parts.

- The water-heating device
- A heat delivery device
- Supply and return piping
- One or more pumps
- Controls

Combined hydronic heating refers to the use of a single water heating device as the heat source for both space and domestic hot water heating. Figure 8-6 illustrates the difference between a hydronic and combined hydronic-heating system using an indirect fired water heater.

The indirect fired water heater supplies domestic hot water. The hot water is heated, indirectly, by the boiler via a heat exchanger in the indirect fired water heater.

An example of a simple combined hydronic-heating system is a storage gas water heater used in conjunction with a fan coil unit (see Figure 8-7). The water heater provides hot water for both domestic use and space heating. A fan coil unit consists of a sheet metal box with supply and return air-duct connections, an internal copper tube and fin heat exchanger, and may also include a fan, pump and controls. When the thermostat calls for heat, the controls energize the pump and fan. The pump circulates hot water from the water heater through the tube and fin heat exchanger and back to the water heater. The fan blows the cool return air across the heat exchanger, transferring the heat from the water to the air. The fan then distributes the heated air throughout the home. Many fan coil units can also have air conditioning added to them.



Compliance/ Plan Check

Hydronic Heating

Complete a DHW-5 worksheet for any project that includes a hydronic space-heating system. This worksheet should accompany all applicable water-heating compliance worksheets. The DHW-5 worksheet is used to determine the effective AFUE for storage gas water heaters and the effective HSPF for storage electric and heat pump water heaters used to supply energy for the combined hydronic space- and water-heating system.

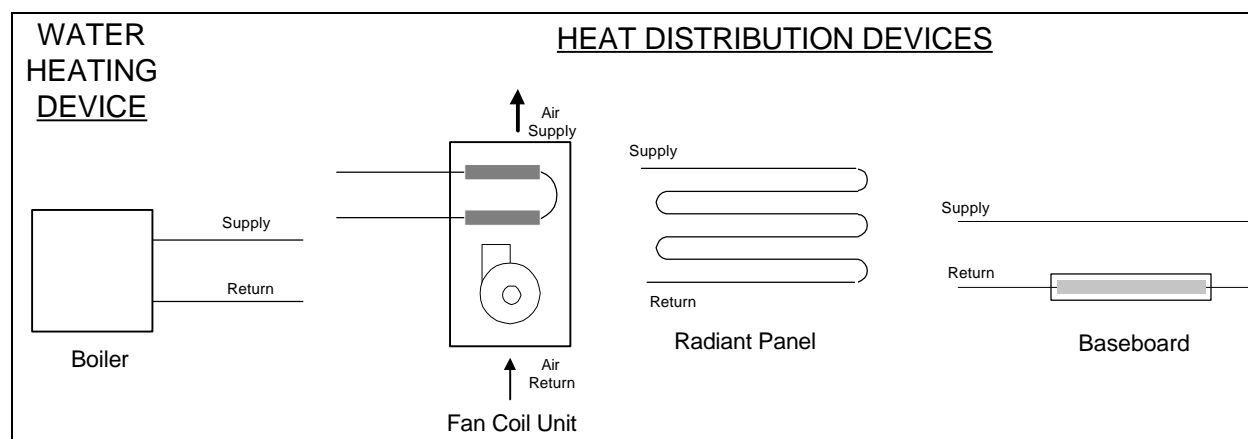


Figure 8-5: Hydronic Heating System Components

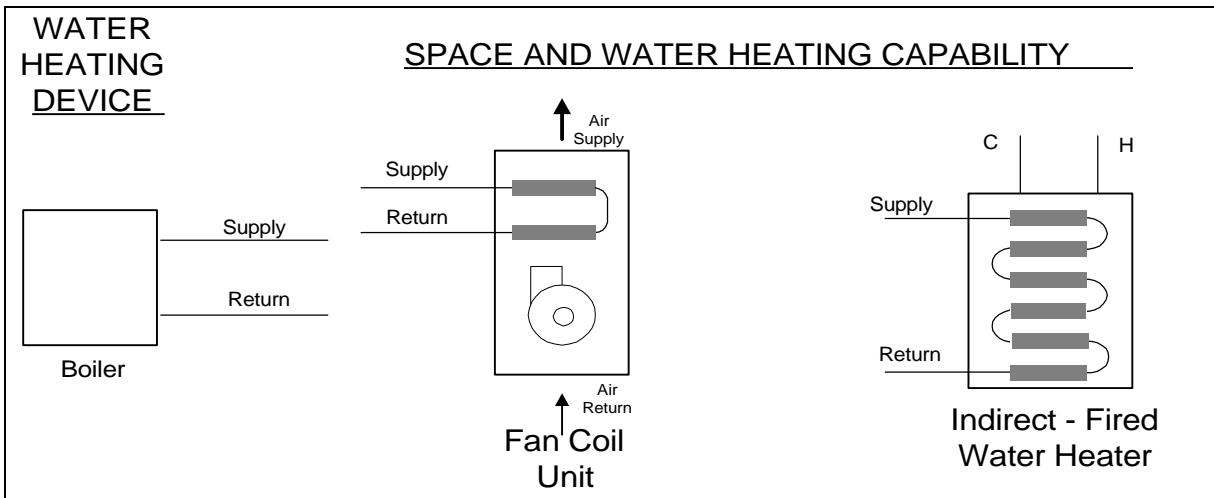


Figure 8-6: Combined Hydronic Heating System

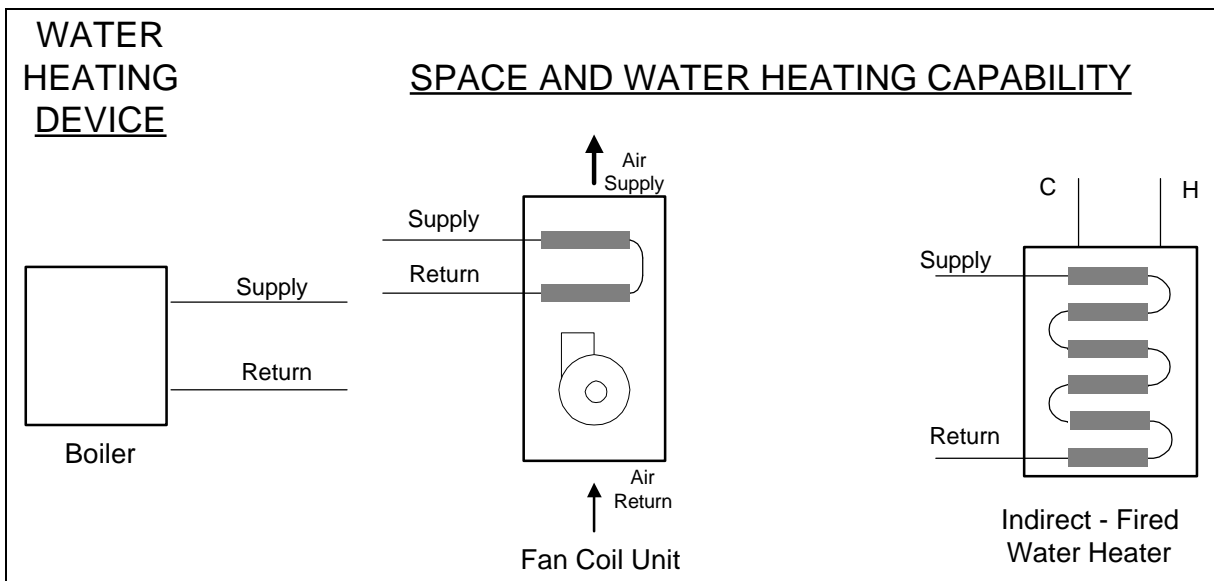


Figure 8-7: Simple Combined Hydronic Heating System

Dedicated Hydronic

When water heater(s) are used for space heating alone (i.e., a separate water heater for domestic hot water), the water heater functions as a boiler.

For showing compliance of dedicated hydronic systems, the AFUE or HSPF of the water heater, as determined in Part 5.5 (DHW-5), is used. This AFUE or HSPF value is used in the packages or for showing compliance with an energy budget. Compliance for the water-heating system is also required.

Combined Hydronic Space- and Water-Heating Systems

When the hydronic space-heating system serves the additional function of providing domestic hot water, the system is analyzed for its water heating performance as if the space heating function were separate. In other words, treat any hydronic system used for water heating the same as any other water-heating system. Input the correct water heater type, auxiliary input credit (if any) and specify the distribution system.

Compliance

An "effective" AFUE or HSPF rating is used to establish space-heating system efficiency. Refer to Chapter 6, Part 6.5 for an explanation of how both water-heating and space-heating system characteristics are accounted for, including the calculation of an Effective AFUE or Effective HSPF rating on the DHW-5 form.

Compliance for a hydronic or combined hydronic-heating system consists of five parts:

1. The water-heating device is typically a boiler or hot water heater.
2. A heat delivery device will be a fan coil, baseboard or radiant panel. Hot water baseboards and radiant panels are normally used for space heating only, and may provide compliance credits since there are no ducts.
3. Supply and return piping.
4. One or more pumps.
5. Controls. Elements of the controls required to operate the system may include a fan and/or pump relay, distribution system zone valves, boiler return water temperature control, and a delivery water temperature controller.

Radiant Floor System

One type of radiant panel distribution system is the radiant floor system, where space heating hot water pipes are set into a concrete slab floor or into a lightweight concrete topping slab laid over a raised floor. R-10 slab edge insulation to a depth of 16" is required for hydronic radiant floor systems in a concrete slab on grade.

NOTE:

The R-10 slab edge insulation is treated as an energy neutral feature. It is not assumed in compliance calculations for credit. R-0 slab edge insulation must be assumed in climate zones 1-15. R-7 is assumed in climate zone 16 only.)

Slab edge insulation applied to basement or retaining walls (with slab below grade) should be installed so that insulation starts at ground level and extends down the required distance.



Construction

Hydronic and Combined
Hydronic Systems

Radiant Floor System/Slab Edge Insulation

When space heating hot water pipes are set into a concrete slab floor R-10 slab edge insulation to a depth of 16" is required. When space heating hot water pipes are set into a lightweight concrete topping slab laid over a raised floor, any portions of the topping slab directly adjacent to a retaining wall must have an R-10 insulation barrier between the topping slab and the wall. Slab edge insulation applied to basement or retaining walls (with slab below grade) should be installed so that insulation starts at ground level and extends down the required distance.



Inspection

Hydronic and Combined Hydronic Systems

Compliance is affected by:

- Water heater or boiler efficiency
- Length of pipe
- Pipe insulation thickness
- Rated input
- Pump Watts (for storage electric).
- Hot water baseboards and radiant panels may provide compliance credits since there are no ducts.
- R-10 slab edge insulation must be installed for a hydronic radiant slab floor heating system.

The system will consist of:

1. Water heating device—water heater or boiler.
2. A heat delivery device—fan coil, baseboard or radiant panel.
3. Supply and return piping.
4. One or more pumps.
5. Controls required to operate the system—may include a fan and/or pump relay, distribution system zone valves, boiler return water temperature control, and a delivery water temperature controller.



Examples

Hydronic and Combined Hydronic

My client wants a dedicated hydronic-heating system (space heating only), but a few things are unclear: (1) What piping insulation is required? (2) Can I use any compliance approach? (3) Do I have to insulate the slab with R-10 slab edge insulation? and (4) What special documentation must be submitted for this system type?

- (1) The supply lines not installed within a concrete radiant floor must be insulated in accordance with Section 150(j)—R-4 on pipes that are 2 inches or less in diameter, R-6 for pipes greater than 2 inches in diameter.
- (2) You can use any compliance approach; however, when using a prescriptive

compliance approach, the AFUE or HSPF (as determined on the DHW-5) must meet the minimum efficiency of the selected Alternative Component Package. NOTE: CALRES requires that a boiler be used as the water heating device for a dedicated hydronic system.

- (3) The R-10 slab edge insulation is only required when the distribution system is a radiant floor system (pipes in the slab). When this is the case R-10 insulation, installed to the lesser of 16 inches deep or the depth of the footing, is a mandatory measure (no modeling or credit).
- (4) A DHW-5 worksheet is used to determine the system efficiency (AFUE or HSPF) and must be submitted with other compliance documentation for prescriptive compliance. As noted in Chapter 6, Table 6-2, approved programs perform the water heating calculations internally, so the DHW forms do not need to be submitted.

What are the slab edge insulation requirements for a hydronic-heating system with the hot water pipes in the slab?

The requirements for slab edge insulation can be found in Sections 150(l) and 151(f)1. of the standards and Chapters 2 and 8.

Material and installation specifications:

- R-10 installed to a depth of 16 inches or to the depth of the footing, whichever is less
- Protected from physical damage and ultra-violet light deterioration
- Water absorption rate no greater than 0.3 percent (ASTM-C-271)
- Water vapor permeance no greater than 2.0 per/inch (ASTM-E-96-90)

Modeling assumption:

Do not model or calculate R-10 insulation; it is a mandatory requirement for this type of heating system. Instead assume R-0 in climate zones 1 through 15, or R-7 in climate zone 16.

8.10 EVAPORATIVE COOLING



Introduction

Evaporative Cooling

Evaporative coolers provide cooling to a building by either direct contact with water (direct evaporative cooler), or a combination of a first stage heat exchanger to pre-cool building air temperature and a second stage with direct contact with water (indirect/direct evaporative cooler).

When selecting evaporative cooling, the following characteristics should be considered:

- Direct evaporative coolers in climates that are both hot and humid may result in uncomfortable indoor humidity levels.
- Indirect/direct evaporative coolers do not increase indoor humidity as much as direct systems, and would be unlikely to produce uncomfortable indoor humidity levels, even in hot, humid areas.
- Evaporative coolers may not reduce indoor temperatures to the same degree as air conditioning.

Credit for evaporative coolers is allowed in either single-family detached or single-family attached residences, not in multi-family buildings.



Compliance/
Plan Check

Evaporative Cooling

Evaporative coolers may be used with any compliance approach. Using a performance approach, credit is provided in either single-family detached or single-family attached residences. To take the credit, assume that there is a standard central air conditioner (with R-4.2 ducts in the attic) with an SEER rating of 11.0 for direct systems and 13.0 for indirect/direct systems. The same SEERs can be used for evaporative coolers installed with or without backup air conditioning [see multiple HVAC systems in Chapter 5 (computer compliance)].



Construction

Evaporative Cooling

To receive credit at the efficiencies listed above, the evaporative cooling system must meet the following requirements:

Eligibility and Installation Criteria

1. Evaporative cooler ducts must satisfy all requirements that apply to air conditioner ducts.
2. Thermostats are required. If air conditioning is installed in conjunction with an evaporative cooler a two-stage thermostat with time lock-out is required.
3. Automatic relief venting must be provided to the building.
5. Evaporative coolers must be permanently installed. No credits are allowed for removable window units.
6. Evaporative coolers must provide minimum air movement at the minimum stated air delivery rate certified with the tests conducted in accordance with the Air Movement and Control Association (AMCA) Standard 210 (see Table 8-1 below).

Table 8-1: Minimum Air Movement Requirements for Evaporative Coolers

Climate Zones	Minimum Air Movement ¹ (cfm/sf)	
	Direct	Indirect/Direct
1 - 9	1.5	1.2
10 - 13	3.2	1.6
14 - 15	4.0	2.0
16	2.6	1.3

¹ If backup air conditioning is installed, the minimum air movement for all climate zones is 1.0 cfm/sf.

8.11 GEOTHERMAL (GROUND SOURCE) HEAT PUMP



Introduction

Geothermal/Ground Source Heat Pumps

A geothermal or ground source heat pump uses the earth as a source of energy for heating and as a sink for energy when cooling. Some systems pump water from an aquifer in the ground and return the water to the ground after transferring heat from or to the water. A few systems use refrigerant directly in a loop of piping buried in the ground. Those heat pumps that use either a water loop or pump water from an aquifer have efficiency test methods that are accepted by the Energy Commission. These efficiency values are certified to the Energy Commission by the manufacturer and are expressed in terms of heating Coefficient of Performance (COP) and cooling Energy Efficiency Ratio (EER).



Compliance/
Plan Check

Geothermal Heat Pump

To determine compliance with the residential standards, the COP and EER must be converted to HSPF and SEER

When equipment is not tested for SEER, the EER may be used in place of the SEER. When heat pump equipment is not tested for HSPF:

$$\text{HSPF} = (3.2 \times \text{COP}) - 2.4$$



Construction

Geothermal Heat Pump

The efficiency of geothermal heat pump systems is dependent on how well the portion of the system in the ground works. Manufacturer's recommendation must be followed carefully to assure that the system is appropriately matched to the soil types and weather conditions.

Local codes may require special installation practices for the ground installed portions of the system. Verify that the system will meet local

code conditions before choosing this type of system to meet the standards.

8.12 DUCT (HVAC) EFFICIENCY



Introduction

Duct Efficiency

Compliance credit for duct (HVAC) efficiency is covered in detail in Chapter 4. Appendix J, *Procedures For HVAC System Design and Installation*, gives optional additional details on the design and installation of energy efficient duct systems.

8.13 RADIANT BARRIERS



Introduction

Radiant Barriers

A radiant barrier is material that either reflects radiant heat or inhibits the emission of radiant heat. Aluminum foil or plastic with a reflective film coating are examples of such a material. Installation of radiant barriers has the greatest savings potential during the cooling season, although they provide some heating benefit as well.

The Energy Commission has approved an energy credit for radiant barriers meeting specific eligibility and installation criteria.



Compliance/
Plan Check

Radiant Barrier

The radiant barrier energy credit is an adjustment to the ceiling U-value when the ceiling is adjacent to an attic with a radiant barrier. The credit is automatically applied by modeling a radiant barrier in an approved computer program with this optional capability. (See the Alternative Calculation Methods (ACM) Manual for Residential Buildings for the equations used to apply the radiant barrier credit.)

NOTE:

If HVAC ducting is present in the attic, an *additional* energy credit is allowed. See ACM Manual, Appendix F.

Indicate the radiant barrier on the CF-1R under “special features.”



Construction

Radiant Barrier

Below are the parameters for receiving credit for a radiant barrier, including criteria for the installation, ventilation and material, all of which contribute to the performance of the radiant barrier.

Installation

The following conditions are required:

- Securely installed in a permanent manner with the shiny side (the side with low emittance) facing down toward the attic floor.
- Installed to the roof truss/rafters (top chords) in **any** of the following methods, with the material:
 - >> Draped over the truss/rafter (the top chords) before the upper roof decking is installed.
 - >> Spanning between the truss/rafters (top chords) and secured (stapled) to each side.
 - >> Secured (stapled) to the bottom surface of the truss/rafter (top chord). A minimum air space must be maintained between the top surface of the radiant barrier and roof decking of not less than 1.5 inches at the center of the truss/rafter span.
 - >> Attached [laminated] directly to the underside of the roof decking. The radiant barrier must be laminated and perforated by the manufacturer to allow moisture/vapor transfer through the roof deck.

See Figure 8-8 for several examples of radiant barrier installations.

- ASTM C-1158-90 is the Standard for Use and Installation of radiant barrier systems.
- Installed according to appropriate requirements:
 - >> C-1224-93 Standard Specification for Reflective Insulation for Building Applications;
 - >> C-727-90 Standard Practice for Installation and Use of Reflective Insulation in Building Constructions; or
 - >> C-1313-95 Standard Specification for Sheet Radiant Barriers for Building Construction Applications.
- The radiant barrier must be installed to cover all gable end walls and other vertical surfaces in the attic.
- The manufacturer of the radiant barrier must provide test data, documentation, or product labeling showing conformance to certification requirements.

Ventilation

Attic ventilation must be provided to:

- Conform to manufacturer's instructions.
- Provide a minimum free ventilation area of not less than one square foot of vent area for each 150 square feet of attic floor area.
- No less than 30 percent upper vents.
- A minimum gap of 3.5 inches provided at the bottom of the radiant barrier and at the top of the ceiling insulation (except for method 4 above).
- A minimum of six (6) inches (measured horizontally) left at the roof peak to allow hot air to escape from the air space between the roof decking and the top surface of the radiant barrier (except for method 4 above).
- Ridge vents or gable end vents are recommended to achieve the best performance. The material should be cut to allow for full air flow to the venting.

Emissivity

- The emissivity of the radiant barrier must be equal to or less than 0.05. ASTM Test Method C-1371-97 is the Standard.

STATE CERTIFICATION

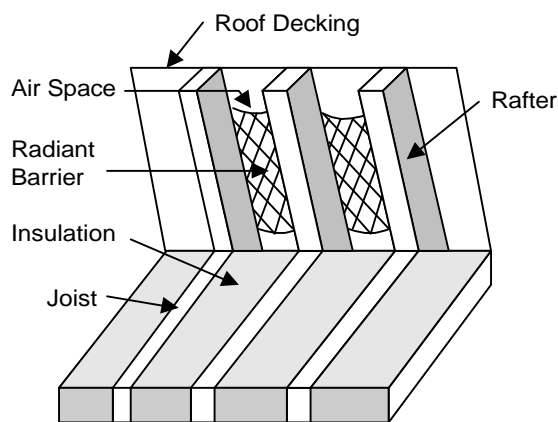
- The radiant barrier manufacturer must be licensed, and the product certified, by the Department of Consumer Affairs, Bureau of Home Furnishings and Thermal Insulation as indicated in the *Consumer Guide and Directory of Certified Insulation Material*.



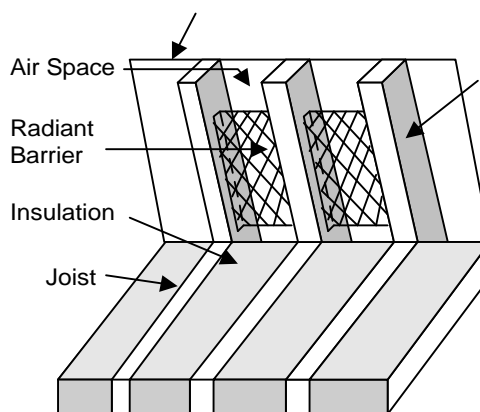
Inspection

Radiant Barrier

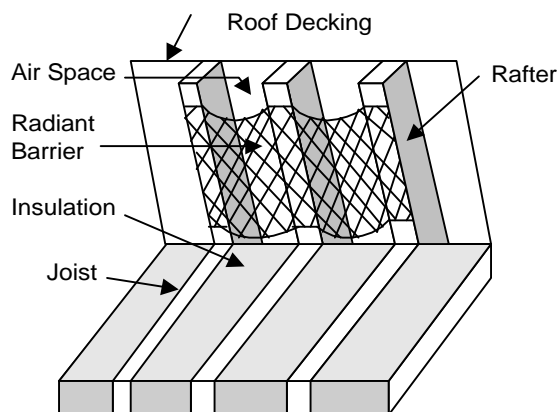
If a radiant barrier was used for compliance credit, check the installation guidelines provided above for the builder. Especially critical are the ventilation and air space requirements that enable the radiant barrier to perform as expected. The product must be labeled as conforming to minimum emissivity requirements.



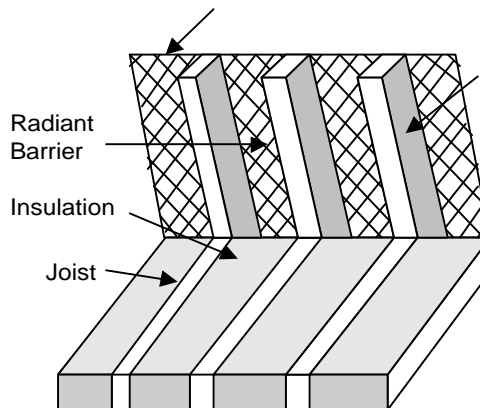
Method 1: Radiant Barrier Draped Over Top of Truss/Rafter



Method 2: Radiant Barrier Attached Between Truss/Rafters



Method 3: Radiant Barrier Attached to Bottom of Truss/Rafter



Method 4: Radiant Barrier Attached to Underside of Roof Deck

Figure 8-8: Radiant Barriers

8.14 INFILTRATION REDUCTION CREDIT—AIR RETARDERS/HOUSEWRAPS



Introduction

Air Retarders (AR)/Housewraps

Infiltration and exfiltration are the intentional or unintentional replacement of conditioned indoor air by unconditioned outdoor air., creating heat gains or heat losses for the building. This exchange of indoor and outdoor air occurs for all buildings to a greater or lesser extent.

Air infiltration or building wrap products do not block the flow of air entirely, allowing water vapor from the inside of the house to exit the building. These products repel liquid water but allow water vapor to pass freely. Water that gets behind the exterior finish material of your house flows down the wrap and exits just below the top of your foundation or slab.

The product is installed on the warm-in-winter side of the insulation and is not recommended in some climates. Other states building codes do not recommend air retarders in hot and humid climate areas where the wet bulb temperature is 67°F or higher for 3,000 or more hours during the warmest six consecutive months of the year. Particularly in such climates, some type of "drainage plane" should be installed on the exterior of the studs. This could be simply 30-pound felt paper, or any low-permeability sheathing material or insulation board.



Compliance/
Plan Check

Air Retarders (AR) No Diagnostic Testing

The computer programs allow infiltration reduction credit for an air retarding wrap without the need for a blower door test. An air retarding wrap can qualify for a default reduction in Specific Leakage Area (SLA) of 0.50 without

confirmation by diagnostic testing (called a prescriptive credit).

The air retarder system must be tested and labeled by the manufacturer to comply with ASTM E1677-95, *Standard Specification for an Air Retarder (AR) Material or system for Low-Rise Framed Building Walls* and have a minimum perm rating of 10.

This credit may not be taken if the user chooses a diagnostic testing target for reduced infiltration. The prescriptive infiltration reduction credit and the air retarder specifications listed above must be listed in the *Special Features and Modeling Assumptions* listings of the CF-1R and CF-2R. The air retarder specifications listed above must also be reported in the *Special Features and Modeling Assumptions*.



Compliance/
Plan Check

Air Retarders With Diagnostic Testing

If the diagnostic testing during construction is specified for either reduced infiltration or reduced infiltration with mechanical ventilation, the ACM must require the user to choose an input menu to enter a target value for measured CFM50_H and, if mechanical ventilation will be used, the wattage and cfm of the ventilation supply and exhaust fans. The AR is not modeled, only the effects of the AR, as represented by the targeted infiltration. The diagnostic testing shall be performed using fan pressurization of the building in accordance with ASTM E 779-1987 (Reapproved 1992), *Standard Test Method for Determining Air Leakage Rate by Fan Pressurization*. The specifications for diagnostic testing and the target values specified above must be reported in the *HERS Required Verification* listings on the CF-1R and CF-2R.



Construction

Air Retarders/Housewraps

Installation

Tape all seams, around windows and other penetrations, and at the slab interface with sheathing tape.

Material/Manufacturer Specifications

An air retarder meeting ASTM E1677 and having a minimum vapor permeance of 10 perms. Test results must be based on the appropriate construction type, either open stud (installed directly over the studs) or shear wall.

Conditions under which the product was tested and the manufacturer installation procedures must be consistent, particularly in the following areas:

1. Installation procedures for seams.
2. If testing is conducted with a cladding over the housewrap or weather barrier, the cladding becomes part of the retarder system and the entire system (housewrap and cladding) is considered the air retarder, not the housewrap by itself.
3. Specifications for how the top and bottom of the wall shall be treated with regard to caulking, gasketing, or tape.

Vapor Permeability Minimums

A minimum water vapor permeance of 10 perms is suggested to reduce the potential for condensation and for trapping moisture. As stated in ASTM-E1677, one of the purposes of an air retarder is to "reduce leakage of moisture laden air through the opaque wall assembly that can create condensation /frost within a wall assembly". Although moisture may still enter the wall assembly by other means, increasing the vapor permeability (or breathability) of the housewrap or weather resistive membrane provides a level of protection by enhancing the drying potential of a wall.

General Installation Guidelines

Installation of whole-house products requires attention to detail. These products need to be installed just like the old tar paper - start from the bottom and let subsequent pieces overlap the lower ones. All seams must be sealed with a special adhesive tape sold by the manufacturer. The wrap needs to be in place before doors and

windows are installed. In fact, it should be installed prior to the placement of the second top wall plate that sits immediately below the roof rafters.

By sandwiching the wrap between the double top wall plate, you virtually eliminate the entry of any soffit down drafts behind the house wrap. Be sure the house wrap extends over the top of the foundation by at least 1 inch.

Some house wrap products can hide the location of wall studs. If you use such a product, be sure to align the outer wall stud markings on the house wrap with the studs. Or consider using a translucent house wrap. Either option will make the job of the bricklayers and siding installers more manageable.



Inspection

Air Retarders without
Diagnostic Testing

Inspection for prescriptive credits:

- Sheets of wrap applied continuously
- All tears or breaks repaired with tape
- All horizontal seams lapped in a shingle-like manner and taped
- All vertical seams lapped and taped
- All windows and penetrations taped or caulked
- Wrap taped or otherwise sealed at slab junction.

8.15 LOG HOMES



Introduction

Log Homes

Log homes are an alternative construction type used throughout the state. Log home companies promote the aesthetic qualities of solid wood construction and can "package" the logs and deliver them directly to a building site. Some companies provide log wall, roof and floor systems with special insulating "channels" or other tech-

niques to minimize the effect of air infiltration between log members and to increase the thermal benefit of the logs alone.

Uninsulated eight-inch solid logs can have an overall thermal resistance equivalent to R-11 insulation (the type of wood is a factor in the R-value). If the wood type of the log is not known, contact the manufacturer to obtain this information.

NOTE:

The mandatory requirement for a minimum of R-13 wall insulation does not apply to unframed walls (e.g., log walls, mass walls).



Compliance/
Plan Check

Log Homes

The thermal mass effects of log home construction can be accounted for within the computer compliance approach (Chapter 5) or prescriptive packages A or C (Chapter 3). Although log walls are not required to be insulated to the level of a framed wall, the effects of the thermal mass (interior and exterior) can compensate for the lack of insulation.

In the computer methods, thermal mass is accounted for when the building envelope is modeled with the specific type of wood (cedar, pine or fir) found in the construction materials section of the computer program. The computer determines the heat capacity of the solid wood/log based upon the wood type and its thickness.

See Chapter 5 and the compliance supplement for the specific computer method being used.

Air infiltration between log walls can be considerably different between manufacturers depending upon the construction technique used. For purposes of compliance, infiltration is always assumed to be equivalent to a wood frame building.

8.16 SOLAR ENERGY SYSTEMS



Introduction

Solar Space Conditioning

This section explains how to demonstrate compliance for solar space conditioning, which requires computer performance compliance (see Chapter 5) and an f-Chart program for analyzing the solar contribution.

Compliance for solar *water*-heating systems is explained in Chapter 6.



Compliance/
Plan Check

Active Solar Space-Heating, f-Chart

To calculate the solar contribution of an active solar space-heating system in meeting the building's annual load, an f-Chart analysis must be performed. In addition, only an approved computer method may be used in conjunction with f-Chart to estimate energy savings of the solar system (see Chapter 6). The computer method should have the capability to report monthly data on space-heating loads. If not, the user will have to input into f-Chart the monthly temperature and heating degree day information for the city where the building is located, as well as the annual UA load of the building.

Approved versions of f-Chart programs are listed in Appendix F.

When using f-Chart, the fixed ambient air and water-main temperatures listed in Chapter 6, Table 6-11 must be used, as well as the modeling values listed in Table 8-2 below.

For active solar space-heating systems, f-Chart analytical methods predict the fraction of the total load which is nonpurchased energy (FNP). FNP is similar to the "solar fraction" (FDHW) predicted by these methods for water heating (see Chapter 6, Part 6.3). When using f-Chart to calculate the performance of active solar space heating, all the appropriate modeling conditions and guidelines indicated by an f-Chart program user's manual

must be followed. The steps for showing compliance is listed below:

1. Model the building using an approved computer method, and print out monthly space-heating loads as well as the annual source Proposed Design Energy Use.
2. Model the active solar system with f-Chart using the monthly space-heating loads from Step 1 as inputs. (Make sure the monthly loads do not include the efficiency of the space-heating system.)
3. Determine the annual space-heating energy savings provided by the active solar system: multiply the annual space-heating energy use load of the proposed design by the FNP, and divide by the AFUE of the proposed heating system.
4. Determine the adjusted space-heating energy use by subtracting the result of Step 3 from the annual space-heating source of the Proposed Design Energy Use (Step 1).

5. Determine whether the building complies by comparing the adjusted total of the Proposed Design Energy Use to the total energy budget of the standard design.



Construction

Solar Space Heating

Solar collectors usually are mounted in rows, on the roof or the south wall of a house. Collectors may also be ground mounted on a collector support structure.

Collectors should face true south, not magnetic south (compass are magnetic south). However, a deviation of 30 degrees or less from true south will not substantially reduce system performance. Collectors should be tilted at an angle equal to the local latitude, plus 15 degrees. Collectors receive the most solar radiation between 9 a.m. and 3 p.m. and should not be shaded by trees, buildings, hills or any other obstructions. Performance can be significantly reduced if even a small portion of the collector area is shaded.

Table 8-2: Active Solar Space-Heating Analysis -- Fixed Input Parameters for f-Chart

Input	Name	Value
C9	Incidence Angle Modifier Constant	0.00
C14	Ground Reflectance	0.20 (or up to 0.90 if documented)
S4	Environment Temperature	70°F
L3	Design Monthly Space-heating Loads loads taken from computer method	Proposed design monthly space-heating analysis report
L4	Tank Set Temperature	135°F
L5	Water Main Temperature	See Chapter 6, Table 6-11
S5	Hot Water Auxiliary Tank UA	0.00



Inspection

Solar Space Heating

As explained in Chapter 6, an f-Chart analysis is required for active solar space-heating systems. Credit for solar space conditioning is applied directly to the energy budget, therefore, any

change impacting the effectiveness of the solar-heating system will affect compliance.

8.17 STRAW BALE CONSTRUCTION



Introduction

Straw Bale Construction

In 1995, the California Legislature passed AB1314, a bill that authorizes all California jurisdictions to adopt building codes for houses with walls constructed of straw bales. The bill provided guidelines for moisture content, bale density, seismic bracing, weather protection, and other structural requirements. In order to demonstrate compliance with the Standards the Energy Commission, in conjunction with other research and testing facilities, determined the thermal properties needed for compliance. The thermal mass benefit of straw bale construction can only be credited through the use of the computer performance compliance approach by modeling straw bale construction using the heat storage and heat capacity characteristics of the straw bales given below.



Compliance/ Plan Check

Straw Bale Construction

Straw bales that are 23 inches by 16 inches are assumed to have a thermal resistance of R-30. (Performance data on other sizes of

bales was not available at the time of publication of this manual.) The minimum density of load bearing walls is 7.0 pounds per cubic foot, this value or the actual density may be used for modeling straw bale walls in computer compliance approaches. Specific heat is set to 0.32 Btu/lb/°F. Volumetric heat capacity (used in some computer programs) is calculated as density times specific heat (at a density of 7 lb/ft³ the volumetric heat capacity is 2.24 Btu/ft³/°F.



Construction

Straw Bale Construction

The minimum dimension of the straw bales when placed in the walls must be 22 inches by 16 inches. There are no restrictions on how the bales are stacked.



Inspection

Straw Bale Construction

Due to the higher resistance to heat flow across the grain of the straws, a bale laid on edge with a nominal 16 inch horizontal thickness has the same R-Value (R-30) as a bale laid flat. When the bale is laid flat the nominal horizontal wall thickness is 23 inches but the heat flows along the grain of the straws resulting in the same R-30 thermal resistance for the bale. Thermal performance data on other sizes of bales was not available at the time of publication of this manual.